THE EISENHOWER LIBRARY
3 1151 02675 9161

158,046

Library

1876

of the Johns Hopkins University

ON THE REACTIONS OF DIAZOALKYLS WITH URAZOLES AND THEIR SALTS.

DISSERTATION

Submitted to the Board of University Studies of
the Johns Hopkins University in Conformity
with the Requirements for the
Degree of Doctor of
Philosophy.

BY

ELI KENNERLY MARSHALL, JR.

Baltimore

1911.

158,046

CONTENTS.

Acknowledgment

Theoretical - - - - - - - - - - - - - - 1

Experimental - - - - - - - - - - - - - 9

- Preparation of compounds used - - - - - - 9
- Alkylations of 1-phenyl-2-methylurazole with diazomethane - - - - - - - 9
- Alkylations of 1-phenyl-2-methylurazole liberated from its sodium salt by alcoholic hydrochloric acid, with diazomethane - - - - - - - - 11
- Alkylations of 1-phenyl-2-methylurazole liberated from its sodium salt by alcohol, with diazomethane - - - - 17
- Alkylations of 1-phenyl-2-methylurazole liberated from its zinc salt by alcoholic hydrochloric acid, with diazomethane - - - - - - - - 18
- Alkylations of 1-phenyl-2-methylurazole liberated from its silver salt by alcoholic hydrochloric acid, with diazomethane - - - - - - - - 19
- Alkylations of 1-phenyl-2-methylurazole, liberated from its double silver-sodium salt by alcoholic hydrochloric acid, with diazomethane - - 22
- Alkylations of 1-phenyl-2-methylurazole with diazoethane - - - - - - - 22
- Alkylations of 1-phenyl-2-methylurazole, liberated from its sodium salt by alcoholic hydrochloric acid, with diazoethane - - - - - - - - 23
- Alkylations of phenylurazole with diazomethane - - - - - - - - - - 24
- Alkylations of 1-phenyl-2-ethylurazole , and 1-phenyl-2-ethylurazole liberated from its sodium salt by alcoholic hydrochloric acid, with diazomethane - - - - - - - - - - 35

Alkylation of 1-phenyl-3-thiolmethylurazole, and 1-phenyl-3-thiolmethylurazole liberated from its sodium salt by alcoholic hydrochloric acid, with diazomethane - - 26

Alkylations of 1-phenyl-4-methylurazole with diazomethane - - - - 27

Alkylations of 1-phenyl-4-methylurazole, liberated from its sodium salt by alcoholic hydrochloric acid, with diazomethane - - - - - - - - - - - 28

Alkylations of 1-phenyl-4-methylurazole with diazoethane - - - - - - - 29

Alkylations of silver salt of 1-phenyl-4-methylurazole - - - - - - - 30

Alkylations of the sodium salt of 1-phenyl-2-methylurazole with methyl nitrate - - - - - - - - 32

Conclusions - - - - - - - - - - - - 34

Biography - - - - - - - - - - - - 35

Acknowledgment.

The author wishes to take this opportunity to express his gratitude to President Remsen, Professor Morse, Professor Jones, Professor Ames, and Associate Professor Acree for the valuable instruction received in lecture room and laboratory.

This work was undertaken at the suggestion of Associate Professor Acree and carried out under his direction. The author is glad of this opportunity to thank him for his constant encouragement and inspiration throughout the work.

ON THE REACTIONS OF DIAZOALKYLS WITH URAZOLES AND THEIR SALTS.

Various theories have been proposed to account for the phenomena of tautomerism. Among these should be mentioned those of Comstock[1], Wheeler[2], Nef[3], and Michael[4]. One necessary fact which all these theories have attempted to explain is how two or more stable, isomeric products can be obtained by the action of a reagent on the tautomeric substance. The various explanations given are very helpful and suggestive, although not necessarily in their final state of development if considered in the light of the large amount of quantitative data accumulated in this laboratory in connection with the tautomeric urazoles and their derivatives. It appears that in all cases in which these urazoles or their salts give two or more stable, isomeric products as the result of a reaction, they do so because they exist, (A) in one tautomeric form alone which yields two or more derivatives through independent side reactions[5]; or (B) in two or more forms in equilibrium, each of which gives its own derivative through an independent reaction.

The following work was started with the idea of

---

[1] Ber. d. chem. Ges., 23, 2274; Amer. Chem. J., 12, 493; 13, 514, 525.

[2] Amer. Chem. J., 21, 187; 26, 135; 30, 28.

[3] Ann. Chem., 261, 52; 276, 200; 277, 59, 88.

[4] J. prakt. Chem., 37, 469; 45, 580; 46, 189; Amer. Chem. J., 43, 322.

[5] For mathematical discussion of the theory in detail see Acree, Amer. Chem. J., 38, 1.

determining, if possible, whether such substances as 1-phenylurazole, 1-phenyl-2-methylurazole, 1-phenyl-2-ethylurazole, 1-phenyl-4-methylurazole, and 1-phenyl-3-thiomethyl-5-oxyurazole exist in only one form, or are really mixtures of two or more tautomeric forms which establish the equilibrium so quickly at ordinary temperature that this rapid change is not shown by the reactions or methods used previously.

The fact[1] that the sodium, potassium, zinc, cobalt, nickel, and manganese salts of the 1-phenyl-4-methylurazole give, when treated with alkyl halides, about the same ratio of N-ester:O-ester, while the silver, lead, and mercury salts give a higher proportion of O-ester, very properly suggests the question whether (A) each salt exists in only one form which yields, when treated with alkyl halides, the two esters by independent side reactions, the velocity constants of which vary with the salt and alkyl halide; or (B) each salt is really a mixture of two or more forms, the equilibrium conditions of which may or may not vary with different salts, and may or may not differ from those of the corresponding acids; such differences would perhaps necessarily cause the different ratios of esters actually obtained.

The slow alkylation reactions and the conductivity methods used up to this time shed no light on this question, as the differences in equilibrium conditions may be too small and the change too rapid to be

---

1. Ber. d. chem. Ges., 41, [illegible]; Amer. Chem. J., 40, 371.

measured. If, however, the acid be liberated from its salt and alkylated at once; and the ratio of esters obtained in this way be compared with that obtained from the acid alone, evidence should be obtained concerning the probability of (A) or (B), provided a sufficiently low temperature and a practically instantaneous alkylating agent be employed. The diazoalkyls react very rapidly with these urazole acids, and give a mixture of N- and O-esters which can be isolated and analyzed. Nirdlinger[1] has shown that 1-phenyl-2-methylurazole yields a constant ratio of esters even when varying molecular concentrations of diazoalkyl are used. When 1-phenyl-2-methylurazole is liberated from its salts by the action of alcohol or hydrochloric acid in the presence of a diazoalkyl, however, a ratio of N-ester:O-ester is obtained, which is, in fact, different from that formed when the urazole acid alone is alkylated under the same conditions of temperature and solvent. But if this same liberated urazole acid is allowed to stand about 15 seconds, and is then treated with diazomethane, the ratio of esters obtained is the same as that formed from the acid alone under the same conditions. Change of concentration of the urazole acid or diazoalkyl does not change the ratio appreciably; the hydrochloric acid, furthermore, effects no change as is shown in the experimental portion. These facts, in connection with those already published[1], seem to exclude the possibility

---

[1] Ber. d. chem. Ges., 41, 3199.

(A) that the urazole acid and salt have only one tautomeric form. The only other question to be considered in this connection is whether both the ions and molecule, or some complex salt, may react with the diazomethane.

$$R\,NH + CH_2N_2 \longrightarrow R\,NCH_3 + N_2$$
$$R\,\overset{-}{N} + \overset{+}{H} + CH_2N_2 \longrightarrow R\,NCH_3 + N_2$$
$$R\,\overset{+}{NH}\cdot H + CH_2N_2 \longrightarrow R\,NCH_3 + N_2 + \overset{+}{H}$$

We must consider the possibility that, at the very moment of the liberation of the urazole acid from the salt, the few molecules of acid present may yield one ratio of esters, and the ions of the acid, which are in great majority, may yield another ratio of esters; while the ions of the urazole acid are combining to form the un-ionized urazole acid we should, therefore, obtain a changing ratio of esters. It would seem probable, however, that when the hydrochloric acid is added to the urazole salt, the ions of the urazole acid would combine practically instantaneously, and hence give the molecular form which would yield the same ratio of esters which we obtained from the acid alone. But my experiments do not give absolute evidence on this point, and until I can complete certain work now planned we must leave this possibility open to question.

In general, however, all the evidence at hand shows such ionic changes to be practically instantaneous[1],

---

[1] Zeit. f. Elek., 14, [illegible].

and this conception (A) seems less likely than the case (B) which I shall now discuss.

Although the ratio of isomeric esters obtained by the action of diazomethane does not represent the ratio of the two tautomers in the original substance, the same ratio should be obtained from the acids or salts if the equilibrium were the same in each. The acid liberated from the salt and allowed to stand gives the same ratio N-ester:O-ester as the acid alone. When the acid is liberated and the diazomethane added quickly, we get a ratio intermediate between that obtained from the acid liberated from the salt in the presence of the diazomethane, and that obtained from the urazole acid alone. We must conclude, therefore, that the salts of 1-phenyl-3-methylurazole have an equilibrium constant which differs from that of the 1-phenyl-3-methylurazole itself.

The 1-phenyl-4-methylurazole and diazomethane give about equal amounts of N- and O-esters. Its salts seem to have the same or very nearly the same equilibrium constants as the free acid. The two tautomeric forms in this case are much more sensitive to changes in solvent, or concentration and temperature than the 1-phenyl-3-methylurazole. 1-phenyl-3-ethylurazole and 1-phenyl-3-thiomethylurazole, when alkylated with diazomethane, give ratios of N-ester:O-ester which are practically the same as those obtained when the acids are liberated from their sodium salts in the presence of diazomethane.

All the salts of 1-phenyl-3-methylurazole investigated (the sodium, zinc, and silver) give practically the same ratio of N-ester:O-ester when treated with hydrochloric acid in the presence of diazomethane. This shows the equilibrium constants to be approximately the same for all of these salts, as previously stated. The silver, lead and mercury salts, however, when treated with methyl iodide give a much higher percentage of O-ester than the other salts. These salts, however, are only slightly soluble in the alcohol-water mixture used. It might be possible that this difference in the ratio of esters is due to the fact that in one case the salts are used in heterogeneous mixture, while in the other in homogeneous mixture. But I have now found that the silver salt gives approximately the same ratio N-ester:O-ester whether suspended or dissolved. This may be due to the fact that the ions and mols are concerned in the reactions to different extents for the different salts, evidence for which view has been obtained by Nirdlinger, Rogers, Robertson and myself with other compounds.

If there are two tautomeric forms in equilibrium

$$\begin{array}{ccc} \underset{c}{R\,NH} & \longleftrightarrow & \underset{a}{R\overset{-}{N}} + \overset{+}{H} \\ \updownarrow & & \\ \underset{d}{R\,OH} & \longleftrightarrow & \underset{b}{R\overset{-}{O}} + \overset{+}{H} \end{array}$$

we must consider whether the mols or ions or both react with the alkyl halides or diazoalkyls. We have already discussed the possibility that in the concentrated solutions of the urazole salt the acid present due to hydrolysis

may have a ratio of ions and also of the molecular forms which differs from that of the acid alone. If this holds, then the change in the ratio of esters discussed above is at once clear. But if such an abnormal hydrolysis is impossible, as both A. A. Noyes and Dr. B.B. Turner believe to be the case[1], then we must look to the differing velocity constants of the reactions between the molecules and the ions of the two tautomeric urazoles with the diazoalkyl. This is at once clear if we consider the above equations. If $\frac{C}{a} = K\frac{a}{b}$ represent the normal equilibrium constants, K may be equal to, less than, or greater than, unity. If K = 1, then, obviously, the same ratio of esters must always be obtained from the urazole acid alone, or from the urazole acid produced by the hydrolysis of the salt, or by the action of hydrochloric acid on the salt. This is true whether the mols or ions of the urazole acid react with the diazoalkyl, provided that the change from the ionic to the molecular forms is practically instantaneous as discussed above. This case seems to apply to 1-phenyl-4-methylurazole, 1-phenyl-3-ethylurazole, and 1-phenyl-3-thiolmethylurazole.

If on the other hand, K>1, as seems to be probable with 1-phenyl-3-methylurazole, the RNH acid is weaker than the ROH acid. When the salt is treated with hydrochloric acid, the ratio $\frac{RNH}{ROH}$ formed by the sudden union of the $\overset{+}{H}$, $R\bar{N}$, and $R\bar{O}$ ions is less than $\frac{c}{a}$. Therefore, if

---

[1] I am indebted to both of these colleagues for many valuable suggestions in this discussion.

practically only the mols of the urazole furnish the esters, we should expect to obtain a ratio N-ester:O-ester smaller than the normal one, if this solution is treated with diazomethane before the tautomers change into the normal condition of equilibrium. This is actually found experimentally to be the case. If, on the other hand, the acidified solution is allowed to stand 15 seconds or more, the tautomers change into the normal state of equilibrium and the normal ratio of esters is obtained. The abnormal ratio of esters obtained from the diazoalkyl and the urazole salt may be due to the hydrolysis of the salt and the immediate reaction of the liberated (molecular) acid with the diazoalkyl present, or may be due to the reaction of the urazole ions or undissociated salts with the diazoalkyl, the alcohol furnishing the hydrogen ions necessary to give a methyl ester. Neither explanation is the more probable in view of the fact that Nirdlinger[1] found that a mixture of the urazole acid and the urazole salt yields a ratio of esters (90:10) intermediate between that from the acid alone (94:6) and that obtained from the salt (87:13).

---

[1] Amer. Chem. J., 43, 375.

EXPERIMENTAL.

Phenylurazole.- This was made according to the method described by Acree[1]. It melted at 263°-265° without decomposition.

Phenyl-2-methylurazole.- This was made as described by Nirdlinger and Acree[2]. A second lot was made from phenylurazole and di-methyl sulphate[3].

Phenyl-4-methylurazole.- This was some which had been previously made by Dr. J. M. Johnson.

ALKYLATIONS OF 1-PHENYL-2-METHYLURAZOLE WITH DIAZOMETHANE.

Alkylations of 1-phenyl-2-methylurazole were carried out by Nirdlinger[4] and the constancy of the ratio N-ester:O-ester with varying amounts of diazomethane shown. His work, however, was carried out at room temperature (about 22°). So it was necessary to see if the ratio N-ester:O-ester was constant with change of temperature.

The method used in the following experiments was similar to that used by Nirdlinger. It is described in detail further on.

---

[1] Amer. Chem. J., 38, 56.
[2] Ibid., 43, 368.
[3] Ibid., 38, 153.
[4] Ibid., 43, 372.

Experiment 1.- 20 cc. of ethyl alcohol containing 0.200 gram of 1-phenyl-2-methylurazole and 30 cc. of ethereal diazomethane solution. Temp. 0°.

Conc. diazo sol. Vol. N.	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0087	0.0488	0.0462	94.6	5.4
0.0174	0.0951	0.0905	95.1	4.9
0.0264	0.1746	0.1636	93.7	6.3
0.0348	0.2135	0.1998	93.1	6.9

Mean, N-ester = 94.1.

Mean, O-ester = 5.9.

Ratio, N-ester:O-ester = 15.9

Experiment 2.- 18.3 cc. of ethyl alcohol containing 0.100 gram of 1-phenyl-2-methylurazole, 30 cc. of ethereal diazomethane solution, and 1 mol. hydrochloric acid in 1.7 cc. alcohol. Temp. 0°.

Conc. diazo sol. Vol. N.	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0174	0.0470	0.0462	96.2	3.8

Experiment 3.- 20 cc. of ethyl alcohol containing 0.100 gram 1-phenyl-2-methylurazole, 20 cc. of ethereal diazomethane solution added. Temp.-70°.

Conc. diazo sol. Vol. N.	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0174	0.0993	0.036	94.2	5.8

ALKYLATIONS OF 1-PHENYL-2-METHYLURAZOLE, LIBERATED FROM ITS SODIUM SALT BY ALCOHOLIC HYDROCHLORIC ACID, WITH DIAZOMETHANE.

All ether used was dried with sodium wire, and the alcohol with lime and redistilled. The alcoholic hydrochloric acid was made by the method of Acree and Brunel[1]. The diazomethane was made in the usual way from methyl nitrosourethane as described by Von Pechmann[2]. The ethereal distillate containing the diazomethane was made up to a definite volume, an adequate portion pipetted out, and its strength determined. In all the experiments, except a few of the last ones, this was accomplished by titration with N/10 ethereal iodine solution and aqueous sodium thiosulphate. This method, however, as shown by the authors elsewhere, gives results which are always too high in expressing the strength of the diazo solution. A method was then devised which consists of letting the diazo solution act on a weighed amount of some organic acid dissolved in ether, diluting with water and determining the excess of acid with standard barium hydroxide solution and phenolphthalein. This method is accurate to 2 or 3% and is described in detail elsewhere[3]. It is also there shown that diazo solutions decompose rapidly on standing, probably acting with some alcohol obtained as an impurity in their preparation. The procedure adopted in the

---

[1] Amer. Chem. J., 36, 117.

[2] Ber. d. chem. Ges., 27, 1888; 28, 855.

[3] Ber. d. chem. Ges., 43, 2323.

experiments was as follows: One tenth of a gram of the sodium urazole salt was weighed out in a small Erlenmeyer flask, holding about 75 cc., and dissolved in 18.3 cc. of alcohol. The diazo solution of required concentration was then placed in a similar flask. In these experiments the flasks were placed in a mixture of water and ice, and after the solutions were cooled to 0°, the diazomethane was added to the solution of the urazole. One mol. of alcoholic hydrochloric acid in 1.7 cc. was then quickly added to the mixture from a pipette, and the whole was shaken thoroughly. The different reactions taking place here account for the small and sometimes varying yield of esters obtained under apparently similar conditions. The diazomethane and the hydrochloric acid react to form methyl chloride; the hydrochloric acid reacts on the urazole salt, liberating the free urazole acid, which then reacts with the diazomethane to form a mixture of N- and O-esters. Although the experimental conditions are apparently the same, the changes take place so rapidly that, before mixing is complete, the diazomethane probably reacts with the hydrochloric acid nearly to the exclusion of the formation of urazole esters. Special experiments with hydrochloric acid, urazoles, and diazoalkyls support this view.

The flask containing the ether-alcohol solution was attached to a condenser and the solvent distilled off carefully on the water bath. Small capillary tubes sealed at both ends were used successfully to avoid

bumping. When only 5 to 10 cc. of solvent remained, this was transferred by means of chloroform to a small extraction funnel containing a few drops of alkali. The ester was then extracted with six portions of chloroform, transferred to a weighed dish, and the chloroform evaporated off as already described.[1] The dish was then dried to constant weight in a vacuum desiccator containing sulphuric acid and paraffin. After the ester was weighed, it was transferred with chloroform to a tube, hydrolyzed, and the N-ester determined as described by Brunel, Johnson and Hirdlinger.

The experiments at low temperature were carried out in the same manner, only Dewar bulbs were used containing a mixture of solid carbon dioxide and ether. The temperature was measured with a pentane thermometer, and averaged about -70°.

Experiment 1.- 16.5 cc. of ethyl alcohol containing 0.200 gram sodium salt of 1-phenyl-2-methylurazole, 60 cc. ethereal diazomethane added, and then 1 mol. hydrochloric acid in 3.5 cc. alcohol. Temp. 0°.

Conc. diazo sol. Vol. N.	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
.0348	0.0425	0.0373	87.7	12.3

Ratio N-ester:O-ester = 7.1

---

[1] Ber. d. chem. Ges., 41, 3222; Amer. Chem. J., 43, 358.

Experiment 2.- 18.5 cc. of ethyl alcohol containing 0.100 gram sodium salt 1-phenyl-2-methylurazole, 30 cc. ethereal diazomethane solution added, and then 1 mol. hydrochloric acid in 1.7 cc. alcohol. Temp. 0°.

Conc. diazo sol. Vol. N.	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
.0174	0.0291	0.0247	84.8	15.2
.0348	0.0325	0.0275	84.6	15.4
.0174	0.0309	0.0271	87.7	12.3

Experiment 3.- 16.5 cc. of ethyl alcohol containing 0.100 gram of sodium salt of 1-phenyl-2-methyl urazole, 30 cc. diazomethane added, and then 2 mols. hydrochloric acid in 3.3 cc. alcohol. Temp. 0°.

Conc. diazo sol. Vol. N.	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0174	0.0141	0.120	85.1	14.9

Experiment 4.- 18.14 cc. ethyl alcohol containing 0.100 gram sodium salt 1-phenyl-2-methylurazole, 30 cc. ethereal diazomethane solution added, and then 1 mol. acetic acid in 1.86 cc. alcohol. Temp. 0°.

Conc. diazo sol. Vol. N.	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0348	0.0360	0.0317	88.2	11.8

Experiment 5.- 18.5 cc. ethyl alcohol, containing 0.100 gram sodium salt 1-phenyl-2-methylurazole, treated with 1 mol. hydrochloric acid in 1.7 cc. alcohol, then immediately with 30 cc. ethereal diazomethane

solution. Temp. 0°.

Conc. diazo sol. Vol. N.	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0174	0.0759	0.0691	91.0	9.0

Experiment 6.- 18.3 cc. of ethyl alcohol, containing 0.100 gram sodium salt of 1-phenyl-2-methylurazole, treated with 1 mol. hydrochloric acid in 1.7 cc. alcohol, and then immediately with 20 cc. ethereal diazomethane solution. Temp. 0°.

Conc. diazo sol. Vol. N	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0262	0.0623	0.0571	91.9	8.1

From last two experiments:

Average per cent. N-ester = 91.5
Average per cent. O-ester = 8.5

Ratio N-ester:O-ester = 10.8

Experiment 7.- 18.3 cc. of ethyl alcohol, containing 0.100 gram of sodium salt of 1-phenyl-2-methylurazole, treated with one mol. hydrochloric acid in 1.7 cc. alcohol, and then after 20 minutes with 30 cc. ethereal diazomethane solution. Temp. 0°.

Conc. diazo sol. Vol. N	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0174	0.0768	0.0723	94.1	5.9

Ratio N-ester:O-ester = 15.9

Experiment 8.- 18.3 cc. of ethyl alcohol, containing 0.100 gram of sodium salt 1-phenyl-2-methylurazole, 20 cc. ethereal diazomethane added, and then 1 mol. hydrochloric acid in 1.7 cc. alcohol. Temp. -70°.

Conc. diazo sol. Vol. N.	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0262	0.0680	0.0600	88.2	11.8

Experiment 9.- 18.3 cc. of ethyl alcohol, containing 0.100 gram of sodium salt of 1-phenyl-2-methylurazole, 1 mol. of hydrochloric acid in 1.7 cc. alcohol added, and then immediately 20 cc. ethereal diazomethane solution. Temp. -70°.

Conc. diazo sol. Vol. N	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0262	0.0620	0.0570	91.9	8.1

Experiment 10.- 18.3 cc. of ethyl alcohol containing 0.100 gram of sodium salt 1-phenyl-2-methylurazole, 1 mol. hydrochloric acid in 1.7 cc. alcohol added, and then after 15 seconds, 20 cc. ethereal diazomethane solution. Temp. -70°.

Conc. diazo sol. Vol. N	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0262	0.0771	0.0730	94.6	5.4

ALKYLATIONS OF 1-PHENYL-2-METHYLURAZOLE, LIBERATED FROM ITS SODIUM SALT BY ALCOHOLYSIS, WITH DIAZOMETHANE.

In a preliminary experiment some sodium salt (about 0.100 gram) was dissolved in 20 cc. ethyl alcohol, treated with ethereal diazomethane solution and allowed to stand. The ether and alcohol were distilled off and residue extracted with chloroform in the usual way: 0.0372 grams of total product was obtained, and gave on hydrolysis 0.0325 gram nitrogen ester, showing a ratio N-ester:O-ester of 87.3:12.7. The most probable explanation is alcoholysis of the salt. If this were so, the amount of ester should increase with time the solution is allowed to stand. This is shown to be so by the following table. The fact, however, that about 0.0083 grams was obtained on distilling off the solvent at once might suggest the supposition that the sodium salt was impure, containing free urazole acid. Some of the salt was extracted with chloroform and 1-phenyl-2-methylurazole obtained. But this was found to show nothing, as chloroform readily decomposes, especially in light, into hydrochloric acid and phosgene under the influence of the oxygen of the air. However, if the unextracted salt contained any free acid, it should give a higher percentage of N-ester when treated with diazomethane and hydrochloric acid than the salt which had been extracted with chloroform. The two specimens were found to give ratio of N-ester:O-ester identical within the experimental error.

Experiment 1.- 20 cc. of ethyl alcohol containing 0.100 gram of sodium salt of 1-phenyl-2-methylurazole, 30 cc. ethereal diazomethane solution added, and allowed to stand at room temperature.

Time in hours	Conc. diazo sol. Vol. N	Weight of total product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0	0.0174	0.0083	------	----	----
20	0.0174	0.0124[1]	0.0258	83.8	16.2
45	0.0174	0.0184			
90	0.0174	0.0212	0.0188	88.6	11.4

ALKYLATIONS OF 1-PHENYL-2-METHYLURAZOLE, LIBERATED FROM ITS ZINC SALT BY ALCOHOLIC HYDROCHLORIC ACID, WITH DIAZOMETHANE.

The zinc salt was prepared as follows: Pure 1-phenyl-2-methylurazole was titrated with the theoretical amount of pure barium hydroxide solution, using phenolphthalein as an indicator. The solution of the barium salt thus formed was treated with the theoretical quantity of pure zinc sulphate, dissolved in a little water. The barium sulphate was filtered off, and the filtrate evaporated to dryness. The residue was powdered and dried at 110°-115°. It is less soluble in water, but more soluble in alcohol, than the corresponding sodium salt.

Experiment 1.- 18.4 cc. of ethyl alcohol containing 0.100 gram of zinc salt of 1-phenyl-2-methylurazole, 30 cc. of ethereal diazomethane solution added, and then

---

[1] Combined and hydrolyzed together.

1 mol. hydrochloric acid in 1.6 cc. of alcohol. Temp. 0°.

Conc. diazo sol. Vol. N	Weight of Total product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0174	0.0952	0.0856	89.9	10.1

Experiment 2.- 18.4 cc. of ethyl alcohol containing 0.100 gram of zinc salt of 1-phenyl-2-methylurazole, 20 cc. ethereal diazomethane solution added, and then 1 mol. hydrochloric acid in 1.6 cc. alcohol. Temp. 0°.

Conc. diazo sol. Vol. N	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0262	0.0946	0.0850	89.8	10.2

Experiment 3.- 18.4 cc. of ethyl alcohol containing 0.100 gram of zinc salt of 1-phenyl-2-methylurazole, 20 cc. of ethereal diazomethane solution added, and then 1 mol. hydrochloric acid in 1.6 cc. alcohol. Temp. -70°.

Conc. diazo sol. Vol. N	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0262	0.0468	0.0416	88.8	11.2
0.0262	0.0048	------	----	----

ALKYLATIONS OF 1-PHENYL-2-METHYLURAZOLE, LIBERATED FROM ITS SILVER SALT BY ALCOHOLIC HYDROCHLORIC ACID, WITH DIAZOMETHANE.

The silver salt was made from the sodium salt by dissolving it in water, and adding a solution containing the required amount of silver nitrate. The white precipitate was filtered off and washed with water, alcohol and ether. The salt is appreciably soluble in

these solvents, and hence as small amounts as necessary should be used in washing. It was then dried quickly by pressing it on a porous plate, and kept in tubes unexposed to the light. In this way it did not darken even after several months standing.

The solubility of this silver salt in alcohol was determined by shaking some of the salt with alcohol for some time, filtering the solution from undissolved salt, and evaporating 10 cc. of the filtrate in a weighed dish. In absolute alcohol 0.148 gram is soluble in 100 cc., or 1 part in 676 parts solvent. Only 0.0200 gram is soluble in 50% alcohol, or 1 part in 500 parts of the solvent.

Except at low temperatures no results were obtained with this salt and diazomethane, owing to the fact that the diazomethane reduced the silver salt to metallic silver, and sufficient ester could not be obtained for analysis. At -70°, however, reduction did not take place; but the salt was reduced, on warming up to room temperature, by the excess of the diazomethane. Experiments to get rid of this excess of diazoalkyle by adding an excess of alcoholic hydrochloric acid or acetic acid after the action was over were successful in preventing reduction, but enough esters could not be obtained in this way for analysis.

In some experiments only a few milligrams of the ester were obtained, and a great number had to be undertaken to obtain one or two satisfactory ones.

After distilling off the mixed solvents the residue was washed onto a small filter and into the extraction funnel by means of chloroform, to free it from

the reduced silver. The solution was made alkaline with ammonia instead of sodium hydroxide. Sometimes finely divided silver was retained by the chloroform, and appeared as a black dust in the esters after evaporation of the chloroform. This was, however, retained in the dish when the esters were transferred to the tube for hydrolysis, and its weight could be ascertained.

Experiment 1.- 18.4 cc. of ethyl alcohol containing 0.100 gram silver salt of 1-phenyl-2-methylurazole, 20 cc. of ethereal diazomethane solution added, and then 1 mol. hydrochloric acid in 1.4 cc. alcohol. Temp. -70°.

Conc. diazo sol. Vol. N	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0262	0.0290	0.0255	87.9	12.1
0.0262	0.0345[1]	0.0300	86.9	13.1

---

[1] This is the combined weight of esters obtained from two similar experiments. In the first, 0.0238 gram was obtained mixed with finely divided silver. In the second, an excess of hydrochloric acid was added 30 seconds after mixing the other materials and 0.0123 gram was obtained. On washing the two into a third dish they weighed 0.0345 gram. This fact shows that the black substance weighed .0006 gram.

ALKYLATION OF 1-PHENYL-2-METHYLURAZOLE, LIBERATED FROM DOUBLE SILVER-SODIUM SALT, WITH DIAZOMETHANE.

This salt was prepared by neutralizing 1-phenyl-2-methylurazole suspended in water with N/5 sodium hydroxide, then adding one half the theoretical amount of silver nitrate dissolved in water. The precipitate first firmed redissolved. The solution was placed over night in a vacuum desiccator, and a white substance crystallized out. This was filtered off, washed with water, and dried on a clay plate, and then in a vacuum desiccator. This salt is very soluble in both water and alcohol.

Experiment 1.- 20 cc. of ethyl alcohol, containing 0.100 gram of silver-sodium salt of 1-phenyl-2-methylurazole, 10 cc. ethereal diazomethane solution added, and then 1 mol. alcoholic hydrochloric acid. Temp. 0°.

Conc.diazo sol. Vol. N	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0524	0.0506	0.0448	88.5	11.5

ALKYLATIONS OF 1-PHENYL-2-METHYLURAZOLE WITH DIAZOETHANE.

The diazoethane was made from ethyl nitrosourethane by the method used for the preparation of diazomethane[1]. The yield was smaller than that of diazomethane.

---

[1] von Pechmann, Ber. d. Chem. Ges., 31, 2643.

This is probably due to the fact that diazoethane decomposes much more rapidly in the presence of water or alcohol than does diazomethane[1].

Experiment 1.- 20 cc. of ethyl alcohol containing 0.100 gram 1-phenyl-2-methylurazole, 30 cc. ethereal diazoethane solution added. Temp. 0°.

Conc. diazo sol. Vol. N	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0174	0.1154	0.0779	67.5	32.5
0.0174	0.1144	0.0785	68.6	31.4

Average N-ester = 68%
Average O-ester = 32%

Ratio N-ester:O-ester = 2.12.

ALKYLATIONS OF 1-PHENYL-2-METHYLURAZOLE, LIBERATED FROM ITS SODIUM SALT BY ALCOHOLIC HYDROCHLORIC ACID, WITH DIAZOETHANE.

Experiment 1.- 18.3 cc. of ethyl alcohol containing 0.100 gram sodium salt of 1-phenyl-2-methylurazole, 30 cc. ethereal diazoethane solution added, and then 1 mol. hydrochloric acid in 1.7 cc. alcohol. Temp. 0°.

Conc. diazo sol. Vol. N	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0174	0.0243	0.0152	62.5	37.5
0.0174	0.0227	0.0137	60.3	39.7

Average per cent. N-ester = 61.4
Average per cent. O-ester = 38.6

Ratio N-ester:O-ester = 1.59.

---

[1] Ber. d. Chem. Ges., 43, 2329.

ALKYLATIONS OF PHENYLURAZOLE WITH DIAZOMETHANE.

The solubility of phenylurazole in absolute ethyl alcohol was determined by shaking an excess with 50 cc. of the solvent, filtering and evaporating 10 cc. of the filtrate to dryness in a weighed dish. 10 cc. saturated solution gave on evaporation 0.070 gram. Therefore, the solubility is 7 grams for 1000cc. of ethyl alcohol.

The solution of phenylurazole in alcohol was treated with diazomethane, and the solvent distilled off in the usual manner. The residue, after transference to an extraction funnel, was made alkaline, and extracted with chloroform. This extract gave the amount of the di-alkyl products formed. The solution was then acidified, and extracted to obtain the mono-alkyl derivatives-- 1-phenyl-3-methyl-, 1-phenyl-4-methyl-, 1-phenyl-3-methoxy-, and 1-phenyl-5-methoxy-urazole. The percent of the two N-esters in the above mixture was determined in the usual manner by hydrolysis.

20 cc. of ethyl alcohol containing 0.140 gram 1-phenylurazole, 1 mol. ethereal diazomethane solution added. Tempt. 0°.

Weight of di-alkyl products.	Weight of mono-alkyl products.	Weight of mono-N-esters	Per cent. mono-N-esters	Per cent. mono-O-esters
0.0066	0.0843	0.0427	50.6	49.4
0.0085	0.0814	0.0454	55.7	44.3

These two results are only approximate and probably a little low, as it was found that the mono-alkyl esters could not be completely extracted out by chloroform even after ten extractions in place of the

usual five or six. Attempts were made to use acetylene di-chloride in place of chloroform, but these gave no better results. In general, chloroform seems to be the better solvent for these substances. Owing to the difficulty in extracting the reactions products, and in analyzing them, no further experiments were undertaken with phenylurazole or its sodium salts.

ALKYLATION OF 1-PHENYL-2-ETHYLURAZOLE WITH DIAZOMETHANE, AND OF 1-PHENYL-2-ETHYLURAZOLE LIBERATED FROM ITS SODIUM SALT BY ALCOHOLIC HYDROCHLORIC ACID, WITH DIAZOMETHANE.

The 1-phenyl-2-ethylurazole used was some which had been previously made by Dr. R. F. Brunel[1]. The sodium salt was made by suspending 1 gram of the acid in water, and titrating with pure N/5 sodium hydroxide. The solution was evaporated to dryness and the salt dried at 100° - 110°.

Experiment 1.- 20 cc. of ethyl alcohol containing 0.100 gram 1-phenyl-2-ethylurazole, 20 cc. ethereal diazomethane solution added. Temp. 0°.

Conc. diazo sol. Vol. N	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0262	0.1065	0.0965	90.6	9.4

Experiment 2.- 18.3 cc. of ethyl alcohol containing 0.100 gram of the sodium salt of 1-phenyl-2-ethylurazole, 20 cc. ethereal diazomethane solution added, and then 1 mol. hydrochloric acid in 1.7 cc. alcohol. Temp. 0°.

1.

Conc. diazo sol. Vol. N	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0262	0.0491	0.0450	91.3	8.2

This experiment seems to prove that (1) the acid liberated from the sodium salt has the same equilibrium conditions as the free acid, or (2) that it changes practically instantaneously into this condition of equilibrium. This contrast to the behavior of the homologous 1-phenyl-2-methylurazole is very marked for such a slight difference in composition.

ALKYLATION OF 1-PHENYL-3-THIOMETHYLURAZOLE, AND OF 1-PHENYL-3-THIOMETHYLURAZOLE LIBERATED FROM ITS SODIUM SALT WITH HYDROCHLORIC ACID, WITH DIAZOMETHANE.

Experiment 1.- 20 cc. of ethyl alcohol containing 0.100 gram 1-phenyl-3-thiomethylurazole, 10 cc. ethereal diazomethane solution added. Temp. 0°.

Conc. diazo sol. Vol. N	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0324	0.0228	0.0147	64.4	35.6

Experiment 2.- 13.4 cc. of ethyl alcohol containing 0.100 gram sodium salt of 1-phenyl-3-thiomethylurazole, 10 cc. ethereal diazomethane added, and 1 mol. hydrochloric acid in 1.6 cc. alcohol. Temp. 0°.

Conc. diazo sol. Vol. N	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0324	0.0260	0.0168	64.6	35.4

Experiment 3.- 0.100 gram 1-phenyl-3-thiol-methylurazole in solid form, treated with 3 mols. ethereal diazomethane solution. Temp. 20°.

Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0995	0.0695	69.8	30.2

This change of ratio from the 64.4% N-ester in the 35% alcohol-ether to the 69.8% N-ester in the ethereal solution is probably due to the influence of the change of solvent, as was found by Nirdlinger when he worked with 1-phenyl-2-methylurazole in water, methyl alcohol, ethyl alcohol, acetone, chloroform, ligroin, etc., and as was found by myself in work on 1-phenyl-4-methylurazole described further on in this article.

ALKYLATIONS OF 1-PHENYL-4-METHYLURAZOLE WITH DIAZOMETHANE.

Experiment 1.- 20 cc. of ethyl alcohol containing 0.100 gram of 1-phenyl-4-methylurazole, and 30 cc. of ethereal diazomethane solution added. Temp. 0°.

Conc. diazo sol. Vol. N	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0174	0.0717	0.0413	57.6	42.4
0.0174	0.0717	0.0426	59.4	40.6

Experiment 2.- 20 cc. of ethyl alcohol containing 0.100 gram of 1-phenyl-4-methylurazole, and 20 cc. ethereal diazomethane solution added. Temp. 0°.

Conc. diazo sol. Vol. N	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0262	0.0810	0.0430	53.1	46.9
0.0262	0.0443	0.0244	55.0	45.0

Experiment 3.- 20 cc. of ethyl alcohol containing 0.100 gram of 1-phenyl-4-methylurazole, and 20 cc. of ethereal diazomethane solution added. Temp. -70°.

Conc. diazo sol. Vol. N	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0262	0.0764	0.0514	67.1	32.9

ALKYLATIONS OF 1-PHENYL-4-METHYLURAZOLE, LIBERATED FROM THE SODIUM SALT WITH ALCOHOLIC HYDROCHLORIC ACID, WITH DIAZOMETHANE.

Experiment 1.- 18.3 cc. of ethyl alcohol containing 0.100 gram of the sodium salt of 1-phenyl-4-methylurazole, 20 cc. ethereal diazomethane solution added, and then 1 mol. hydrochloric acid in 1.7 cc. alcohol. Temp. 0°.

Conc. diazo sol. Vol. N	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0174	0.0438	0.0270	61.6	38.4
0.0174	0.0226	0.0138	61.0	39.0

Experiment 2.- 18.3 cc. of ethyl alcohol containing 0.100 gram of the sodium salt of 1-phenyl-4-methylurazole, 20 cc. ethereal diazomethane solution added, and then 1 mol. hydrochloric acid in 1.7 cc. alcohol. Temp. -70°.

Conc. diazo sol. Vol. N	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0262	0.0533	0.0352	66.1	33.9
0.0262	0.0495	0.0322	65.0	35.0

ALKYLATIONS OF 1-PHENYL-4-METHYLURAZOLE WITH DIAZOETHANE.

Experiment 1.- 20 cc. of ethyl alcohol containing 0.100 gram of 1-phenyl-2-methylurazole, and 20 cc. ethereal diazomethane added. Temp. 0°.

Conc. diazo sol. Vol. N	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0232	0.1091	0.0817	74.8	25.2
0.0262	0.1102	0.0841	76.3	23.7

ALKYLATIONS OF 1-PHENYL-4-METHYLURAZOLE, LIBERATED FROM ITS SODIUM SALT BY ALCOHOLIC HYDROCHLORIC ACID, BY DIAZOETHANE.

Experiment 1.- 18.3 cc. of ethyl alcohol containing 0.100 gram sodium salt of 1-phenyl-4-methylurazole, 20 cc. ethereal diazoethane solution added, and then 1 mol. hydrochloric acid in 1.7 cc. alcohol. Temp. 0°.

Conc. diazo sol. Vol. N	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0262	0.0617	0.0450	72.9	27.1
0.0262	0.0587	0.0438	74.6	25.4

Experiment 2.- 20 cc. of ethyl alcohol containing 0.100 gram of 1-phenyl-4-methylurazole and 0.3345 gram sodium salt (3 mols.), and 20 cc. ethereal diazoethane solution added. Temp. 0°.

Conc. diazo sol. Vol. N	Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0262	0.0900	0.0666	74.1	25.9

ALKYLATION OF THE SILVER SALT OF 1-PHENYL-3-METHYLURAZOLE.

As in all the previous alkylations of the silver salts of tautomeric substances the silver salt had been suspended in the solvent[1], these experiments were carried out to get some data on the ratio of N-ester:O-ester when the silver salt was used in solution. The small solubility of the latter, its slow reactivity with all alkylating reagents tried, the coating of the unchanged substance with silver iodide when an alkyl halide was used, and the rapid hydrolysis of the alkylating agent when water-alcohol was used as solvent, made this a somewhat difficult task. The quantity of solvent which could be employed was limited by the fact that the extraction funnels held only about 60 cc., and extraction of the esters from a mixture of alcohol and water containing more than 50~~%~~ percent alcohol was practically impossible. Even with 50~~%~~ percent alcohol, emulsions formed which were hard to break, and about seven or eight extractions were necessary, even when using more chloroform in each extraction than usual.

A large number of experiments were carried out with methyl and ethyl iodides, di-methyl sulphate, and methyl nitrate under varying conditions of solution and temperature. In most of these, however, not enough esters were obtained for analysis, the quantity being in some cases less than 2 milligrams. The concentration of alkylating agent was also varied from 2 or 3 to 30 or 40

---

[1] Amer. Chem. J., 43, 371.

nols. With methyl iodide, by combining the esters obtained from two or more experiments, enough was obtained for hydrolysis. That the precipitated silver iodide did not contain any absorbed ester was shown by grinding up the tube and filter paper used, boiling them with alcohol, filtering and extracting the solution with chloroform.

The silver salts of 1-phenyl-4-methylurazole and 1-phenyl-2-thiomethylurazole were tried, but did not prove as satisfactory as the salt of 1-phenyl-2-methylurazole on account of their lesser solubility.

Experiment 1.- 40 cc. of 50~~%~~ per cent alcohol containing 0.080 gram of the silver salt of 1-phenyl-2-methylurazole treated with 0.5 cc. methyl iodide and allowed to stand at room temperature for 48 hours.

Experiment, same as above, and esters from the two combined.

Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0228	0.0116	50.9	49.1

Experiment 2.- Saturated solution of the silver salt of 1-phenyl-2-methylurazole in 50 cc. of 50~~%~~ per cent ethyl alcohol and excess methyl iodide (1 cc.) allowed to stand at room temperature for 48 hours.

Three more experiments similar to above carried out and esters from the four combined and hydrolyzed.

Weight of Total Product	Weight of N-ester	Per cent. N-ester	Per cent. O-ester
0.0273	0.0125	45.8	44.2

These experiments are very important because

they give us for the first time the proof that, in a heterogeneous or homogeneous mixture, the silver salt yields practically the same ratio of esters. Now the silver and zinc salts yield the same ratio of esters obtained from the sodium salt when first treated with a mineral acid and then with diazomethane, this being evidence that the ratio of the ions (and of mols.) is approximately the same for all salts. This being the case we must look to the possibility of differences in the velocities of the reactions of the ionic and molecular forms of the different salts with alkyl halides to account for the different ratios of N-ester and O-ester obtained from these different salts. This question is now being studied experimentally.

THE ALKYLATIONS OF SODIUM SALT OF 1-PHENYL-2-METHYLURAZOLE WITH METHYL NITRATE.

The methyl nitrate was prepared from a mixture of sulphuric and nitric acids and methyl alcohol by the method of Delephine.[1] It was washed twice with water, in which it is appreciably soluble, then with a dilute solution of sodium carbonate; it was then dried with calcium chloride. When distilled it boiled at 65° - 65.4°.

While the methyl nitrate was found to be unsatisfactory for the alkylation of the silver salt, it was thought desirable to measure the velocity of its reaction with the sodium salt of the 1-phenyl-2-methylurazole, and the ratio of the amounts of isomeric esters

---

[1] Bull. Soc. Chem. de Paris, 13, 1944.

found, and to compare these results with those obtained with methyl iodide.

0.3 Wt. N. Sodium Salt of Phenyl-2-methylurazole and 0.3 Vol. N. Methyl Nitrate at 60°. Solvent 40 per cent methyl alcohol.

t(hours)	A	Total Product	Per cent. N-ester	AK.	AK' N-ester	AK" O-ester
1.	0.307	0.0125	----	0.0392		
3.5	0.307	0.0425	98.9	0.0416		
22.	0.307	0.1559	98.1	0.0401		

The constant for the velocity of the reaction of methyl iodide and the sodium salt under the same conditions is 1.8. Methyl iodide, therefore, reacts with this salt about forty-five times as rapidly as does methyl nitrate. The ratio of the amounts of N-ester and O-ester obtained from methyl iodide[1] is 97:3.

---

1. Amer. Chem. J., 43, 371.

CONCLUSIONS.

1. 1-phenyl-3-methylurazole, 1-phenyl-3-ethylurazole, 1-phenyl-4-methylurazole, and 1-phenyl-3-thiolmethylurazole have been alkylated with diazomethane and diazoethane and the ratio N-ester:O-ester determined.

2. These urazole acids have been liberated from their sodium, zinc and silver salts by alcoholic hydrochloric acid, or alcohol, in the presence of diazomethane and diazoethane and the ratio N-ester:O-ester was measured. Two different ratios of esters have been obtained from 1-phenyl-3-methylurazole, the results depending on whether the acid is alkylated alone or is liberated from its salt and then alkylated *at once*. If the liberated acid is allowed to undergo tautomeric or other changes during 15 seconds and is then alkylated the ratio N-ester:O-ester obtained is the same as that from the acid alone.

3. The causes which might produce such differences in these ratios have been discussed.

4. The 1-phenyl-3-methylurazole liberated from the sodium, zinc or silver salt under the same conditions has been found to give the same ratio of esters.

5. The silver salt of 1-phenyl-3-methylurazole, whether suspended or dissolved, and methyl iodide have been found to give a constant ratio of esters.

6. The velocity constant for the reaction of methyl nitrate with the sodium salt of 1-phenyl-3-methylurazole has been measured.

BIOGRAPHY.

Eli Kennerly Marshall, Jr., the author of this dissertation, was born in Charleston, South Carolina, May 2, 1889. His early education was obtained in private schools of that city, and in 1904 he graduated from the High School. He then entered the College of Charleston, from which institution he received the degree of Bachelor of Science in June, 1908. In the fall of that year he entered the Johns Hopkins University as a graduate student in Chemistry, with Physical Chemistry and Physics as subordinate subjects.